Mars Astrobiological Cave and Internal habitability Explorer (MACIE): A New Frontiers Mission Concept

A white paper planned for the upcoming Decadal Survey on Planetary Science and Astrobiology
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Caves represent one of the best localities for finding evidence of life beyond Earth. These features offer subsurface access without the costs of a deep drilling payload. There have been more than a thousand cave-like features identified on Mars. They formed from volcanic processes (e.g. lava tubes), tectonic processes (e.g. atypical pit crater chains), or both. Numerical heat and mass transfer modeling of the Martian subsurface indicates that equatorial Martian lava tube caves may not only be shielded from cosmic radiation but also host favorable conditions to maintain stable water-ice deposits. Therefore, these features represent significant astrobiological targets on Mars.

MACIE, a New Frontiers class mission concept named after Macie Roberts one of NASA's human computers, will address two science goals: 1) Have habitable conditions ever existed within Martian lava tubes? And 2) did life emerge or seek refuge in Martian lava tubes? We will specifically focus on lava tubes in the Tharsis Region of Mars, which may have been glaciated through most of the Amazonian (to ~300 Mya; Parsons et al., 2020), and some lava tubes in the region are thought to host stable water ice (Williams et al., 2010). We are examining mobility platforms that will allow us to traverse a Martian cave to determine whether there is water and/or water ice present, evidence of present or past aqueous alteration, a radiation environment conducive to life, and nutrients and energy available to support life. MACIE will also determine whether the candidate lava tube contains evidence consistent with past or present life, including molecular complexity of organics, biominerals, biovermiculations, and the presence of biogenic gases. Therefore, this mission concept will address a key recommendation of the 2019 National Academies' Astrobiology Strategy, "NASA's programs and missions should reflect a dedicated focus on research and exploration of subsurface habitability in light of recent advances... [in our understanding of] the history and nature of subsurface fluids on Mars..."

We are currently evaluating the instrument and architecture trade space using mission concept development tools and subject matter experts at NASA JPL and will emerge with a viable CML2-3 concept that will address MEPAG goals (2020): 1) Determine whether life ever existed on Mars and 2) Characterize the climate of Mars. Importantly, if MACIE does not detect evidence of past or present life, it would still provide significant habitability and geology science returns, and enable future use as a human astronaut shelter or base.

We expect to have a full draft of our white paper advocating for MACIE as a New Frontiers mission concept for the next decade by late April 2020. Additional co-authors who focus on lava tube science, Amazonian Mars, habitability and astrobiology, instrumentation, and robotics are welcome, as are co-signers who are interested in supporting the mission concept.

You can co-sign MACIE here. If interested in co-authoring, please contact: clander@swri.org